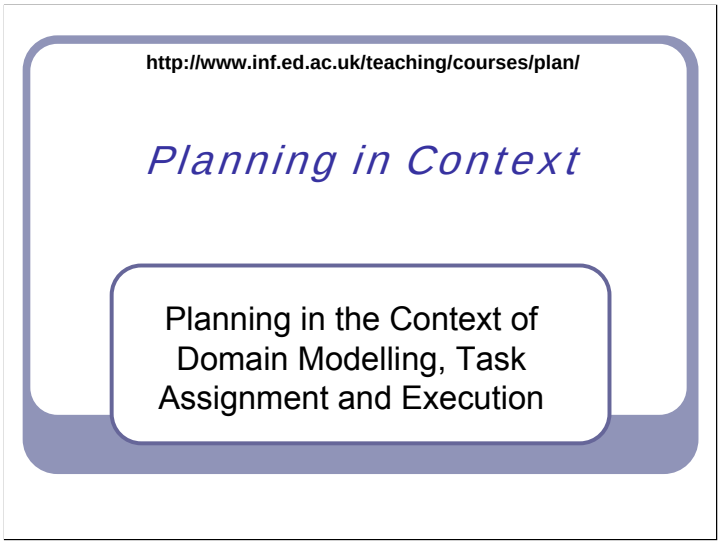
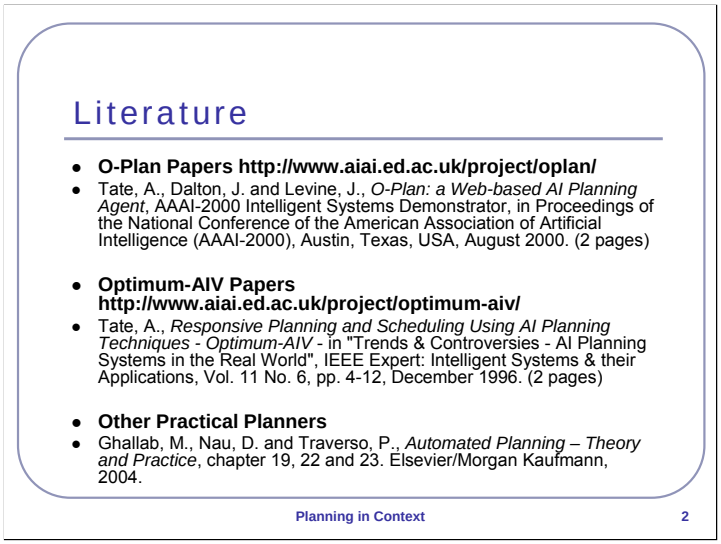


Lecturer: Austin Tate

Date Prepared: 24-Sep-2009



Literature

These 2 short papers will give an overview of some practical planners originating in AIAI at the University of Edinburgh which are in practical use.

The whole of the IEEE Intelligent Systems Trends and Controversies will be used for later reading, but for this lecture, just read the Optimum-AIV description.

O-Plan has been used for a range of practical and research tasks. It was developed form 1983 to 1999 and still runs still runs as a planning service over the web

Optimum-AIV is in use by the European Space Agency for Assembly, Integration and Verification (Test) planning for the Ariane Rocket payload bay. Its design was based on O-Plan algorithms.

Further practical planning systems are described in several chapters of the course textbook… e.g. chapters 19, 22 and 23.

Malik Ghallab, Dana Nau, and Paolo Traverso. *Automated Planning – Theory and Practice*. Elsevier/Morgan Kaufmann, 2004.

Overview

- Practical AI Planners
- Planning in the context of execution
- Nonlin
- O-Plan
- Optimum-AIV
- I-X/I-Plan
- Planning++

Edinburgh AI Planners in Productive Use

http://www.aiai.ed.ac.uk/project/plan/

1975 – Nonlin – UK CEGB - Electricity Turbine Overhaul Procedures

1982 – Deviser based on Nonlin – NASA JPL – Voyager Mission Planning

1996 – OPTIMUM_AIV based on O-Plan – ESA Ariane IV AIV for payload bay

1996-present – Search and Rescue – UK RAF and USA JPRA

Commercial applications for Nynas tanker scheduling and Edify for financial help desks

Overview

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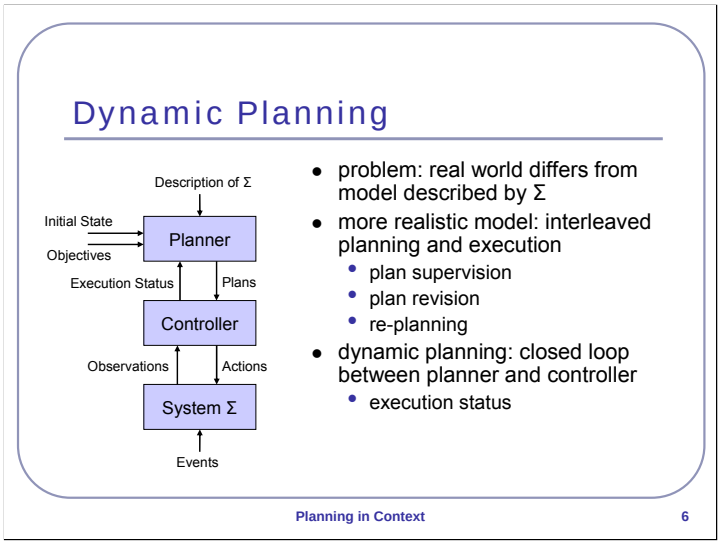


Slide introduced in lecture 1 shows that planning systems are often used in a context where execution of plans is to be done.

Nonlin (1974-1977)

- Hierarchical Task Network Planning
- Partial Order Planner
- Plan Space Planner
- Uses State-Variable (Functional) Representation
- Goal structure-based plan development - considers alternative “approaches” only based on plan rationale
- QA/Modal Truth Criterion Condition Achievement
- Condition “Types” to limit search
- “Compute Conditions” for links to external data and systems (attached procedures)
- Time and Resource Constraint checks

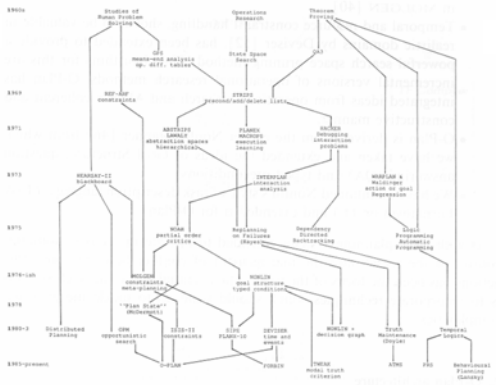
- Nonlin core is basis for text book descriptions of HTN Planning

O-Plan (1983-1999) Features

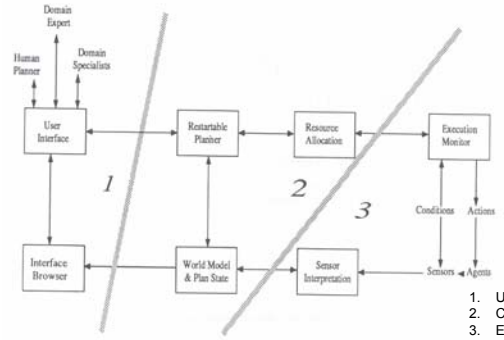
- Domain knowledge elicitation and modelling tools
- Rich plan representation and use
- Hierarchical Task Network Planning
- Detailed constraint management
- Goal structure-based plan monitoring
- Dynamic issue handling
- Plan repair in low and high tempo situations
- Interfaces for users with different roles
- Management of planning and execution workflow

O-Plan has been used for a range of practical and research tasks. It was developed form 1983 to 1999 and still runs still runs as a planning service over the web.

O-Plan (1983-1999) Features

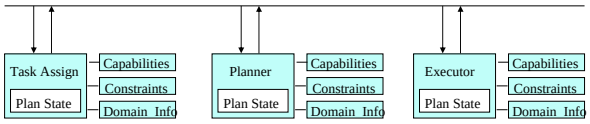


O-Plan Project Components

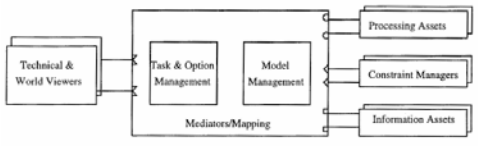


1. User Interface
2. Core Planner
3. Execution System

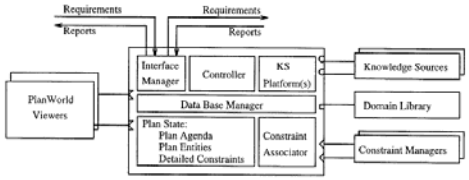
O-Plan 3 Levels



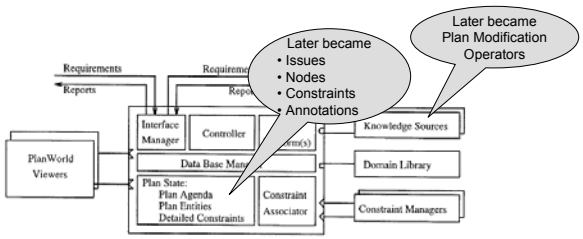
O-Plan Agent Architecture



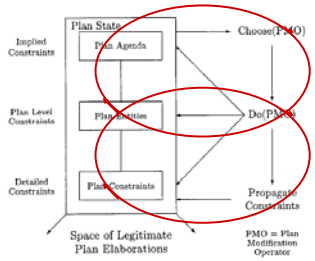
O-Plan Agent Architecture



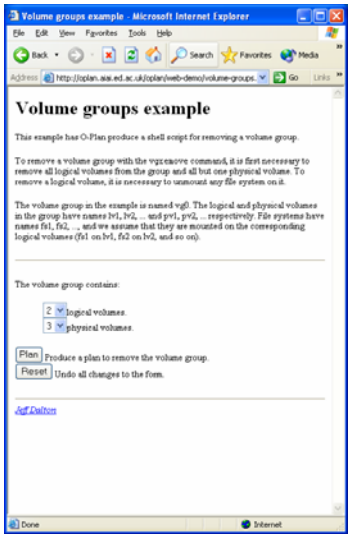
O-Plan Agent Architecture

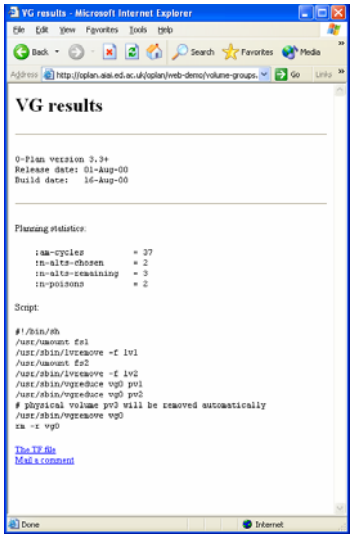


O-Plan Planning Workflow

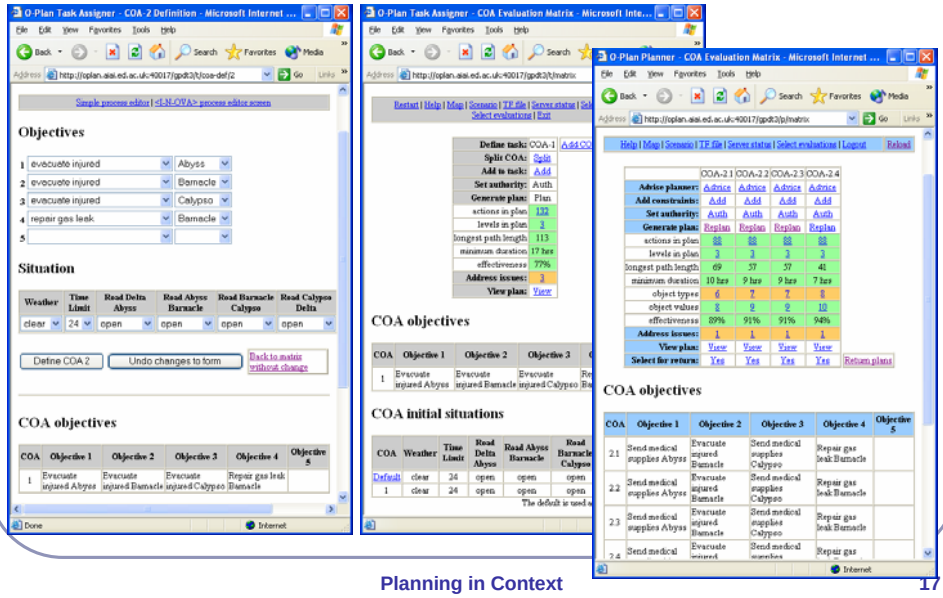


O-Plan Unix Sys Admin Aid





O-Plan MOUT Task Description, Planning and Workflow Aids



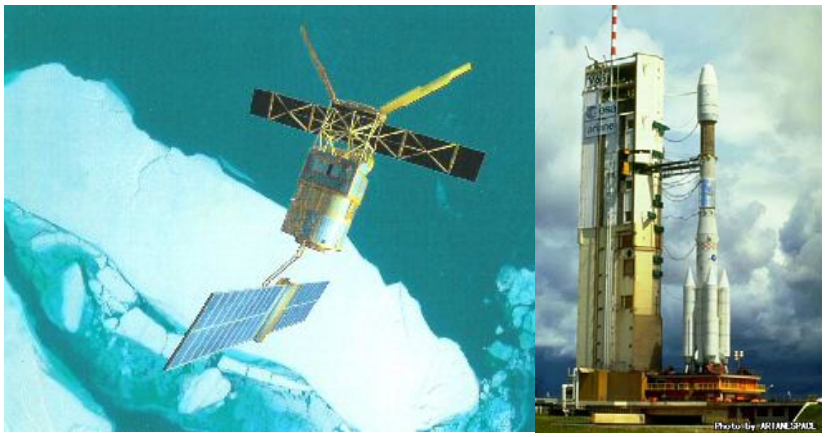
O-Plan Web Service

http://www.aiai.ed.ac.uk/project/oplan/

Check out AAAI-2000 “Introductory Demo” Link

Password for some demos: “show-oplan”

Optimum-AIV



Optimum-AIV is in use by the European Space Agency (ESA) for Assembly, Integration and Verification (Test) planning for the Ariane Rocket payload bay. Its design was based on O-Plan algorithms and earlier development of an AI planner for the ERS-1 Spacecraft.

Optimum-AIV (1992-4) Features

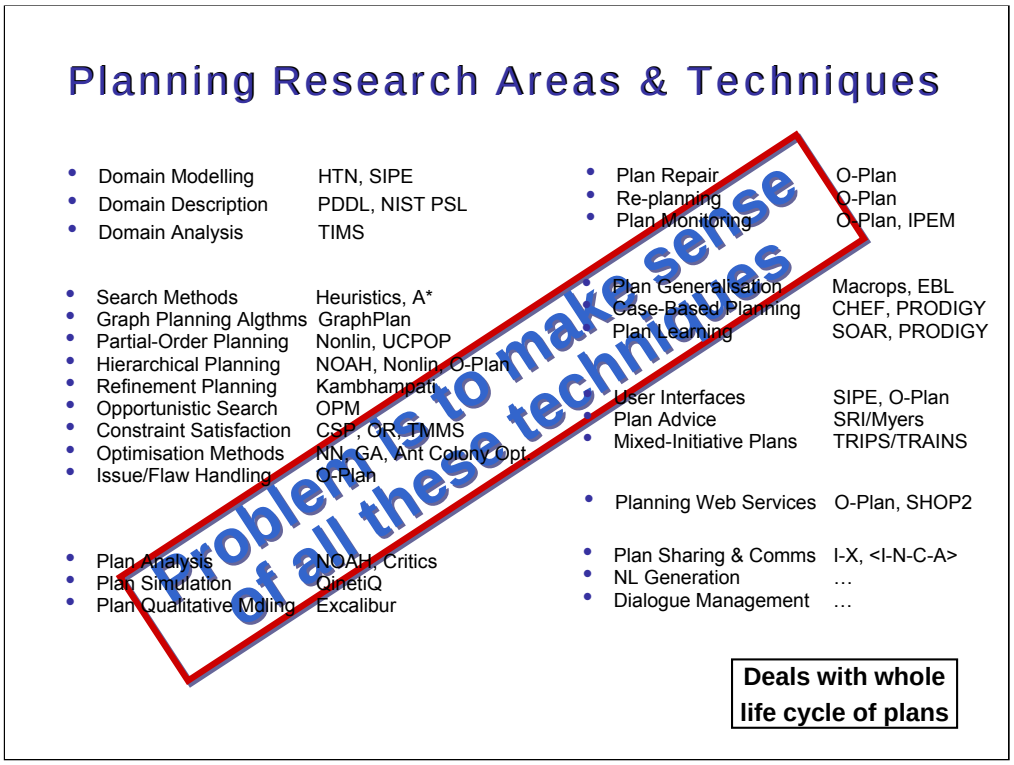
- Rich plan representation and use
- Hierarchical Task Network Planning
- Detailed constraint management
- Planner and User rationale recorded
- Dynamic issue handling
- Plan repair using test failure recovery plans
- Integration with ESA's Artemis Project Management System

Note the similarity to the AI features used in O-Plan.

Planning Research Areas & Techniques

Domain Modelling	HTN, SIPE
Domain Description	PDDL, NIST PSL
Domain Analysis	TIMS
Search Methods	Heuristics, A*
Graph Planning Algthms	GraphPlan
Partial-Order Planning	Nonlin, UCPOP
Hierarchical Planning	NOAH, Nonlin, O-Plan
Refinement Planning	Kambhampati
Opportunistic Search	OPM
Constraint Satisfaction	CSP, OR, TMMS
Optimisation Methods	NN, GA, Ant Colony Opt.
Issue/Flaw Handling	O-Plan
Plan Analysis	NOAH, Critics
Plan Simulation	QinetiQ
Plan Qualitative Mdling	Excalibur
Plan Repair	O-Plan
Re-planning	O-Plan
Plan Monitoring	O-Plan, IPEM
Plan Generalisation	Macrops, EBL
Case-Based Planning	CHEF, PRODIGY
Plan Learning	SOAR, PRODIGY
User Interfaces	SIPE, O-Plan
Plan Advice	SRI/Myers
Mixed-Initiative Plans	TRIPS/TRAINS
Planning Web Services	O-Plan, SHOP2
Plan Sharing & Comms	I-X, <I-N-C-A>
NL Generation	…
Dialogue Management	…

There are many techniques which together offer support for rich planning systems.



In a later lecture we will seek to show that we can have a framework that allows many of these techniques to co-exist and be used in a sensible way.

A More Collaborative Planning Framework

- **Human relatable and presentable objectives, issues, sense-making, advice, multiple options, argumentation, discussions and outline plans for higher levels**
- **Detailed planners, search engines, constraint solvers, analyzers and simulators act in this framework in an understandable way to provide feasibility checks, detailed constraints and guidance**
- **Sharing of processes and information about process products between humans and systems**
- **Current status, context and environment sensitivity**
- **Links between informal/unstructured planning, more structured planning and methods for optimisation**

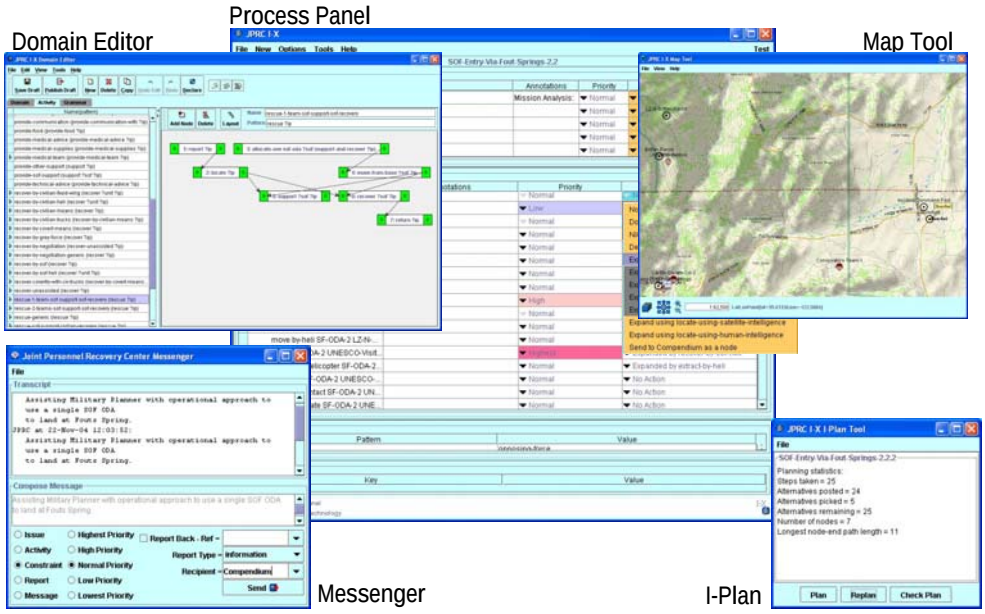
I-X/I-Plan (2000-)

- **Shared, intelligible, easily communicated and extendible conceptual model for objectives, processes, standard operating procedures and plans:**
  - **I Issues**
  - **N Nodes/Activities**
  - **C Constraints**
  - **A Annotations**
- **Communication of dynamic status and presence for agents, and reports about their collaborative processes and process products**
- **Context sensitive presentation of options for action**
- **Intelligent activity planning, execution, monitoring, re-planning and plan repair via I-Plan and I-P^2 (I-X Process Panels)**

I-P^2 aim is a Planning, Workflow and Task Messaging "Catch All"

- **Can take ANY requirement to:**
  - **Handle an issue**
  - **Perform an activity**
  - **Respect a constraint**
  - **Note an annotation**
- **Deals with these via:**
  - **Manual activity**
  - **Internal capabilities**
  - **External capabilities**
  - **Reroute or delegate to other panels or agents**
  - **Plan and execute a composite of these capabilities (I-Plan)**
- **Receives reports and interprets them to:**
  - **Understand current status of issues, activities and constraints**
  - **Understand current world state, especially status of process products**
  - **Help user control the situation**
- **Copes with partial knowledge of processes and organisations**

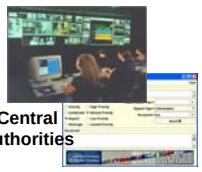
I-X Process Panel and Tools



I-X for Emergency Response

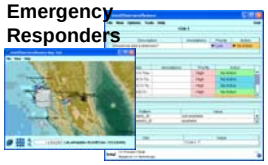
Command Centre

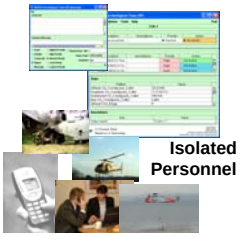
Collaboration and Communication



Central Authorities

Emergency Responders

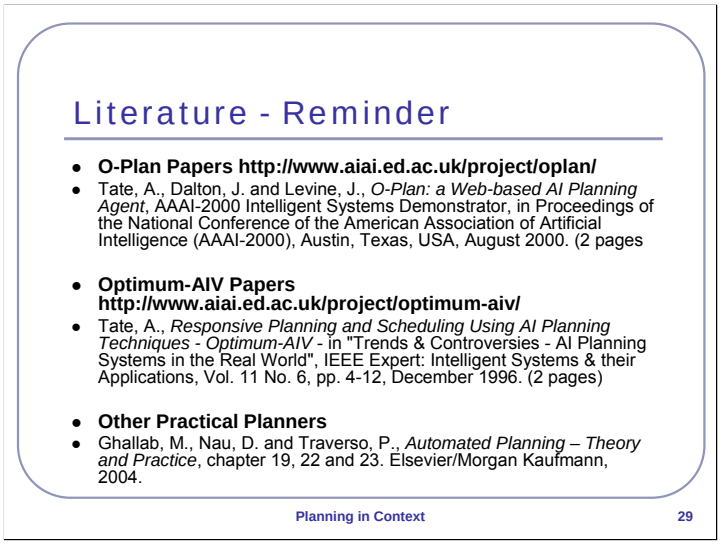




Isolated Personnel

Summary

- Practical AI Planning
- Refinement Planning as a Unifying View
- Nonlin and O-Plan Features
- Planning++
- I-X/I-Plan Overview



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